

S  
627.83  
N7cdm  
2001

# **COTTONWOOD DAM**

## **MANUAL FOR OPERATION AND MAINTENANCE**

STATE DOCUMENTS COLLECTION

2001

MONTANA STATE LIBRARY  
1515 E. 6th AVE.  
HELENA, MONTANA 59620

**State Water Projects Bureau  
Water Resources Division  
Department of Natural Resources and Conservation  
48 North Last Chance Gulch  
P. O. Box 201601  
Helena, MT 59620-1601**

**Originally Published June, 1995  
Revised July 2001**

MONTANA STATE LIBRARY



**3 0864 0015 5124 4**

# **COTTONWOOD DAM**

## **MANUAL FOR OPERATION AND MAINTENANCE**

**State Water Projects Bureau  
Water Resources Division  
Department of Natural Resources and Conservation  
48 North Last Chance Gulch  
P. O. Box 201601  
Helena, MT 59620-1601**

**Originally Published June, 1995  
Revised July 2001**



Digitized by the Internet Archive  
in 2015

<https://archive.org/details/cottonwooddamman2001mont>

# TABLE OF CONTENTS

	<u>Page</u>
OVERVIEW .....	1
General Location Map (Figure 1) .....	3
Project Area Map (Figure 2) .....	4
Dam General Layout Map (Figure 3) .....	5
Monitoring Wells Map (Figure 4) .....	6
STATISTICAL INFORMATION .....	7
OPERATING PROCEDURES .....	11
Method and Schedule of Operation .....	11
Safe Drawdown .....	12
Limits of Appurtenances .....	12
Dam Operator .....	12
Storage Determination .....	13
Weather Monitoring .....	14
Interaction with Other Dams .....	14
Emergency .....	14
INSPECTION AND MONITORING .....	15
Structural Features Inspection .....	15
Riprap Inspection .....	16
Monitoring Wells .....	16
Seepage Monitoring .....	17
MAINTENANCE .....	19
Routine Maintenance .....	19
Annual Maintenance .....	20
Record Keeping .....	20
REFERENCES .....	23
APPENDICES .....	25
A. RATING CURVES AND TABLES .....	A1
Table 1. SLOPE/ELEVATION/STORAGE TABLE .....	A2
Table 2. ACTIVE STORAGE TABLE .....	A3
Table 3. SPILLWAY RATING CURVE AND TABLE .....	A4
Table 4. OUTFLOW RATING CURVE AND TABLE .....	A5
B. INSPECTION REPORT FORM .....	B1
C. O&M MANUAL DISTRIBUTION LIST .....	C1
D. MONITORING WELL LOGS .....	D1
E. PROJECT DRAWINGS .....	E1





## OVERVIEW

Cottonwood Dam is located on Cottonwood Creek, approximately 3 miles northwest of town of Wilsall in Park County. Cottonwood Reservoir impounds runoff from a drainage area of 34 square miles located in Park and Gallatin Counties (See Figures 1 and 2). Figure 3 provides a general layout of the dam, spillway and outlet works. Figure 4 shows the location of the monitoring wells.

The dam is owned by the Montana Department of Natural Resources and Conservation (DNRC) and is managed by the State Water Projects Bureau (SWPB) of the DNRC. The Shields Canal Company (herein called the “association”) operates and maintains the dam.

The earthfill dam and dike were completed in 1953. The dam is 39-feet-high and 610-feet-long while the dike is up to 8-feet-high and 825-feet-long. In 1986 significant construction was completed to rehabilitate the spillway and riprap on the upstream face of the dam. Reports indicate the dam has historically received adequate maintenance.

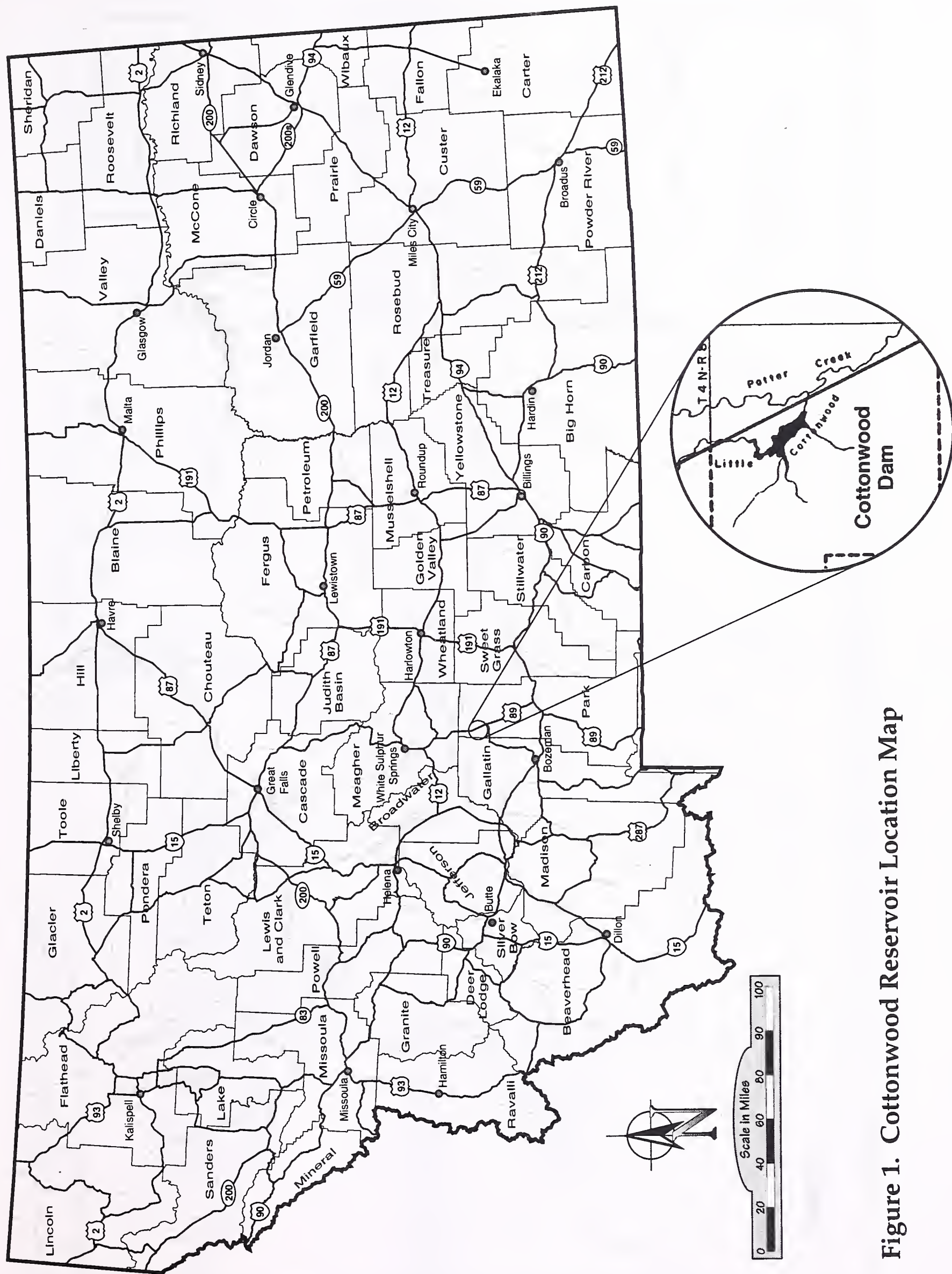
The dam's outlet works consist of a wet tower and a single 36-inch diameter slide gate with controls at the top of the tower. The low-level outlet conduit consists of 197 feet of 10 gauge, 36-inch diameter corrugated metal pipe double bituminous coated (inside and outside) and paved invert.

The spillway is located in the right abutment. The spillway is an uncontrolled concrete chute with 70-foot-wide guard dike and a 20-foot-wide ogee crest at the throat of a 20-foot-wide chute with concrete baffle blocks. The rehabilitation in 1986 added the 70-foot-wide guard dike at elevation 5,102.5, which was the elevation of the wooden flashboards (the flashboards were removed during

the rehabilitation work).

Water from the reservoir is primarily used for irrigation. The reservoir is also used for water-based recreation.





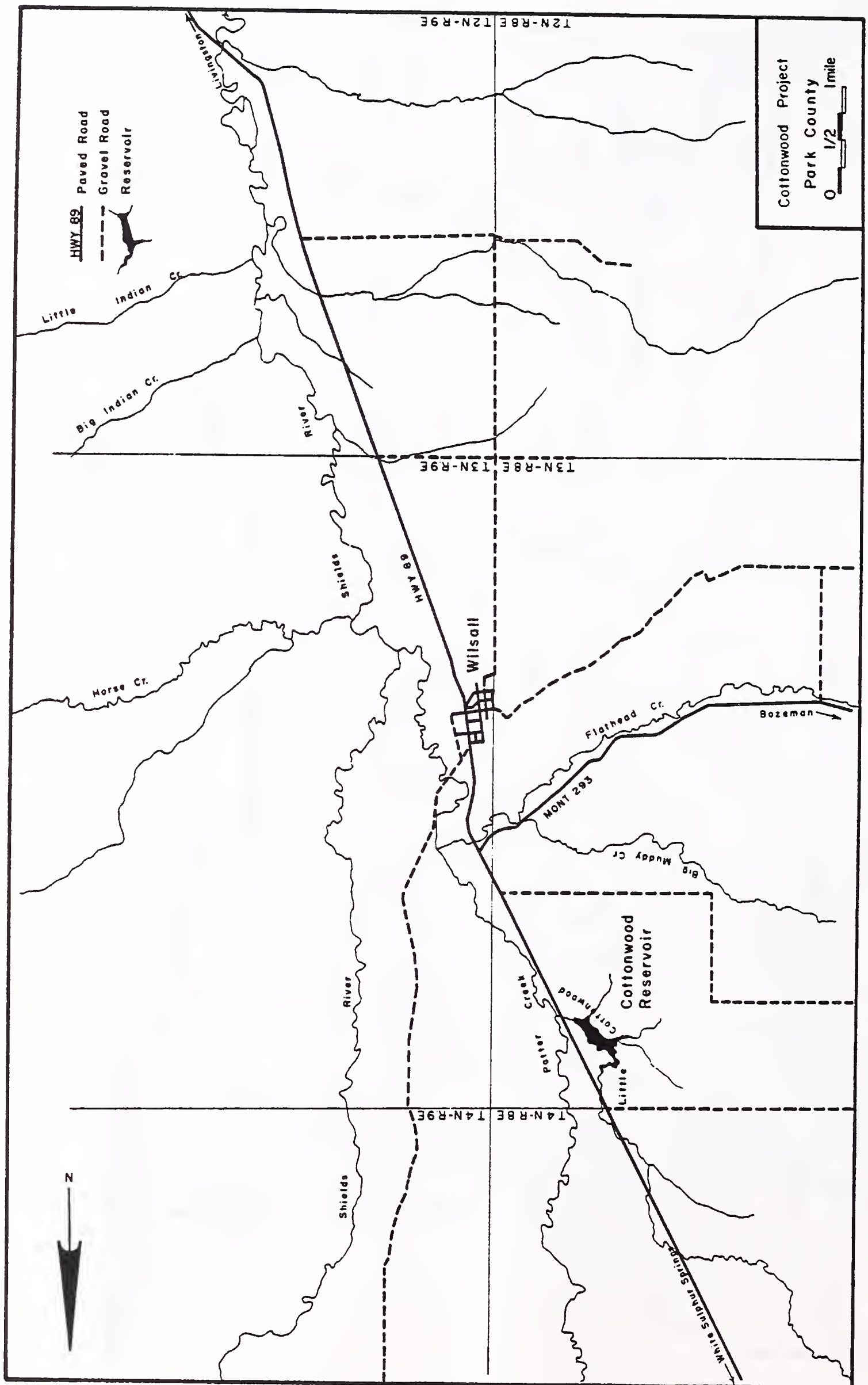


Figure 2. Cottonwood Project Map

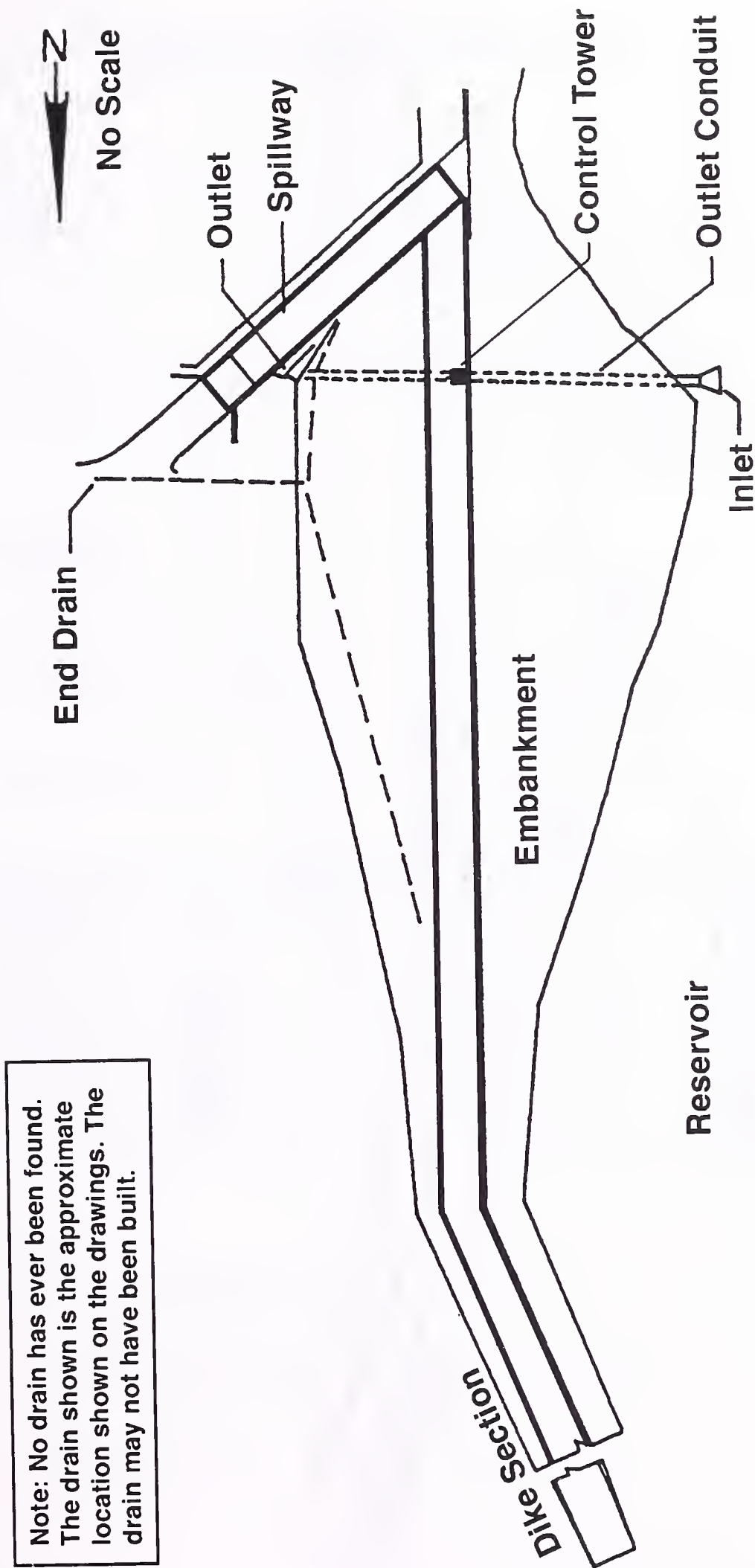


Figure 3. Cottonwood Dam General Layout Map

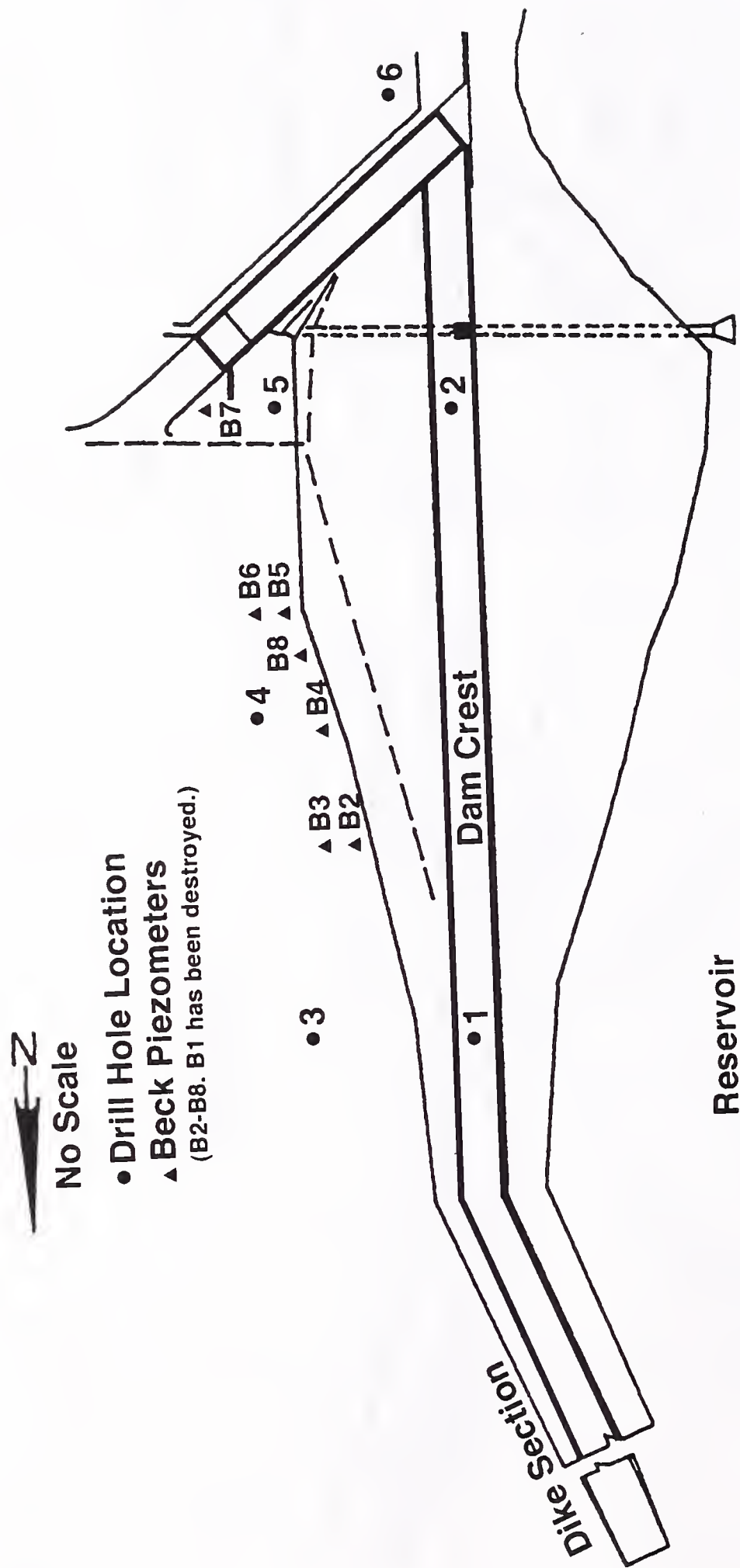


Figure 4. Cottonwood Dam Monitoring Wells Location



## STATISTICAL INFORMATION

### 1. General

a. Owner	Montana Department of Natural Resources and Conservation (DNRC)
b. Operator	Shields Canal Company
c. Location	Sections 1, 2, 11, and 12, Township 3 North, Range 8 East
d. Latitude	46° 02' 00"
Longitude	110° 40' 54"
e. County--State	Park--Montana
f. Watershed Location	Cottonwood Creek (tributary to Potter Creek)
g. Drainage Area	34 square miles

### 2. Principal Elevations (feet above mean sea level)

a. Minimum Dam Crest	5,108.7 feet
b. Normal Full Pool	5,102.5 feet
c. Guard Dike Crest	5,102.5 feet
d. Spillway Ogee Crest	5,100.5 feet
e. Outlet Design Invert	5,072.0 feet

### 3. Reservoir

a. Length of Maximum Pool (approximate)	0.9 mile
b. Maximum Reservoir Level of Record	5103.0 ft (est.)
c. Surface Area at Normal Pool	235 acres

#### **4. Storage**

- |  |                 |
|--|-----------------|
| a. Total Storage<br>(pool at dam crest)                | 3,670 acre-feet |
| b. Active Storage<br>(pool at guard dike crest)        | 1,905 acre-feet |
| c. Maximum Surcharge<br>(from guard dike to dam crest) | 1,765 acre-feet |

#### **5. Hydrology**

- |   |   |
|---|---|
| a. Inflow Design Flood<br>(HKM -- 1986) | 14,200 cfs -- Probable<br>Maximum Flood |
| b. 100-Year Flood                       | 1,120 cfs                               |
| c. 500-Year Flood                       | 1,770 cfs                               |

#### **6. Dam Embankment**

- |                     |  |
|---------------------|--|
| a. Type             | Zoned earthfill                            |
| b. Hydraulic Height | 39 feet                                    |
| c. Crest Length     | 610 feet<br>(includes spillway -- 20 feet) |
| d. Crest Width      | 20-26 feet                                 |
| e. Downstream Slope | 1v on 2.0h                                 |
| f. Upstream Slope   | 1v on 3.0h                                 |

#### **7. Dike Embankment**

- |                     |            |
|---------------------|------------|
| a. Type             | Earthfill  |
| b. Hydraulic Height | 8 feet     |
| c. Crest Length     | 825 feet   |
| d. Crest Width      | 10-18 feet |
| e. Downstream Slope | 1v on 2.0h |
| f. Upstream Slope   | 1v on 4.0h |

## **8. Spillway**

- |  |  |
|--|--|
| a. Location                                | Right abutment                               |
| b. Type                                    | Uncontrolled guard dike with an ogee crest   |
| c. Width                                   | Guard dike - 70 feet<br>Ogee crest - 20 feet |
| d. Chute Width                             | 20 feet                                      |
| e. Maximum Capacity<br>(pool at dam crest) | 1,375 cfs                                    |

## **9. Outlet Works**

- |                                    |  |
|------------------------------------|--|
| a. Size                            | A single 36-inch diameter corrugated steel pipe, 10-gauge, double bituminous coated with paved invert.     |
| b. Length                          | 197 feet   |
| c. Control                         | A single 36-inch diameter vertical slide gate located in a rectangular wet tower with control at dam crest |
| d. Capacity<br>(pool at dam crest) | 112 cfs  |
| e. Trashrack                       | Yes  |





## **OPERATING PROCEDURES**

The Shields Canal Company operates Cottonwood Dam to provide an adequate supply of irrigation water to meet contracts with the water users. Another goal is to insure safe operation of the project.

### **METHOD AND SCHEDULE OF OPERATION**

For most the year, the outlet remains in a closed position. Any snowmelt or other runoff is stored in the reservoir until filled. Water in excess of the storage capacity is simply allowed to discharge over the spillway. According to the dam operator, the spillway spills about seven out of ten years. The date chosen for opening the outlet varies according to the needs of the irrigators, but it will be, generally, near the end of June or first half of July. The gate is typically set to release about 12 to 15 cfs when opened. Releases are then adjusted as needed according to stream conditions and the requirements of the water users. The capacity of the distribution canal limits useable releases to about 18 cfs. The gate is then typically closed before the first of September. The water may be released for May 1 through September 30. The typical total annual drawdown of the reservoir is estimated to be about 12 -15 feet.

**Maximum Winter Storage.** The maximum reservoir elevation for winter storage is 5,097.5 feet with 957 acre-feet of storage. This winter maximum helps prevent damage to the riprap and embankment from wind-driven waves and ice.

**Minimum Winter Storage.** The minimum reservoir elevation for winter storage is 5083.4 feet with 50 acre-feet of storage. This winter minimum helps prevent ice damage to the inlet structure for the outlet works.

## **SAFE DRAWDOWN**

Because of the stability of Cottonwood Dam has not been thoroughly investigated relative to its structural stability, the SWPB recommends that drawdown rates should not exceed one foot per day.

## **LIMITATIONS OF APPURTENANCES**

Appurtenances at Cottonwood dam include the embankment, dike, outlet works, and spillway. At the minimum dam crest elevation, the outlet works capacity is 112 cfs. The maximum gate opening for the outlet gate is 3 feet. Openings in excess of this amount may damage the gate, gate frame, gate stem or the gate-operating pedestal. The 3 feet of operation is measured on the exposed portion of the gate stem between the top of the pedestal and the bottom of the stop nut.

The spillway has a capacity of 1,375 cfs at the minimum dam crest elevation. The spillway-rating table is shown in Appendix A.

## **DAM OPERATOR**

The responsibility for the daily operation of the dam and reservoir rests with the association and its dam operator. The dam operator is generally authorized to operate the reservoir to meet the association's goal of providing storage and regulation in support of agriculture. The dam operator's specific responsibilities are to:

1. Operate the mechanical features of the outlet works.
2. Coordinate filling of the reservoir and the release of water.
3. Notify the SWPB of unusual occurrences such as vandalism, impending flood, excessive seepage, or problems with the outlet.

4. Perform various maintenance tasks.
5. Monitor weather conditions.
6. Monitor seepage.

Typically, the outgoing dam operator, association, and the SWPB train a new dam operator. The dam operator's training focuses on the mechanical operation of the gate, measurement of the storage level, measurement of the rate of water release, and record keeping. The outlet gate is operated manually with a hand crank.

The outlet works are to be used for controlling the releases of irrigation water and not for providing emergency relief.

The dam operator is normally available to observe the dam and perform operating functions weekly during the filling and irrigation season and monthly at other times of the year. Communication among the dam operator, the association, and the SWPB typically takes place by telephone. Although not routinely available, during emergencies or unusual occurrences, radio communication may be established so that the dam operator can speak directly with county authorities and communicate indirectly with the SWPB (**see Cottonwood Dam Action Emergency Plan**).

### **STORAGE DETERMINATION**

Storage in the reservoir and the elevation of the reservoir surface are determined by taking a slope measurement. Measure in feet from the rebar pin located along the north side of the gate operating pedestal concrete pad to the water surface. The elevation of the reservoir surface and the storage can then be found using the Slope-Elevation-Storage Table in Appendix A.

If water is flowing over the guard dike in front of the spillway, the reservoir storage and elevation can be determined by



measuring the depth of the water going over the guard dike. The elevation of the guard dike is 5,102.5 feet. Add the depth of the water going over the guard dike to 5,102.5 to find the elevation of the water surface. Once the reservoir surface elevation is determined, the reservoir storage is found using the Elevation/Storage Table (Table 2) in Appendix A.

### **WEATHER MONITORING**

Weather conditions will be monitored by the dam operator through normal local weather forecasts and the National Weather Service.

If severe flooding is anticipated, the NWS Billings Office **(800-240-4596 or 406-652-2314)** should be contacted for information about the storm, such as the estimated storm intensity and duration, runoff duration (above base flow), and total flood volume of the storm in the Cottonwood Creek drainage.

### **INTERACTION WITH OTHER DAMS**

The only dams located downstream of the Cottonwood Dam are irrigation diversion dams. The safety of these dams is not affected by the operation of Cottonwood Dam during either normal or emergency operations. Therefore, interaction with other dams is not a concern of the normal operation of Cottonwood Dam.

### **EMERGENCY**

If it appears that Cottonwood Dam is about to breach, or during emergency operations, the dam operator will initiate the **Cottonwood Emergency Action Plan.**

## **INSPECTION AND MONITORING**

The SWPB conducts annual inspections of the dam. Appendix B includes an example of a SWPB inspection report form. In addition to annual inspections, SWPB personnel will inspect the dam and reservoir during and after heavy runoff, severe rainstorms, and severe windstorms during high storage periods and after an earthquake. The embankment is not monitored by instrumentation.

### **STRUCTURAL FEATURES INSPECTION**

Structural features include the dam embankment, dike, spillway and outlet works. The SWPB inspects these structures annually as part of its inspection program. Items to be checked or noted include, but are not limited to:

1. Outlet Works
  - a. Any differential settlement or movement resulting in cracking of the conduit.
  - b. Erosion of the seals or corrugated metal pipe by cavitation immediately downstream of the gates
  - c. Major seepage of water into the conduit or emerging at spillway sidewall along side conduit
  - d. Major deterioration of exposed concrete due to freeze/thaw cycles or sulfate reactions
  - e. Operation of the gate through a full cycle
  - f. Corrosion of any metal
  - g. Proper lubrication of pedestal
  - h. Unobstructed operation of the air vent
2. Embankments
  - a. Erosion gullies in dam and dike faces.
  - b. Damage from burrowing animals or vegetation.
  - c. Displacement or loss of riprap protection.

- d. Displacement of fill, sink holes, slumps etc.
  - e. Any seepage.
4. Spillway
- a. Cracking or displacement of the concrete floor, baffle blocks, and sidewalls.
  - b. Seepage into, underneath or along the sides of spillway.
  - c. Excessive sediment or debris at guard dike or ogee crest.
  - d. Erosion, undermining, or unaccountable flow at bottom of spillway.
  - e. General deterioration.
  - f. Blockage of the approach or exit channel.

### **RIPRAP INSPECTION**

The riprap on the upstream face of the dam should be at least 30 inches thick. Immediately after the occurrence of high water, the riprap will be inspected and additional riprap added if needed.

### **MONITORING WELLS**

Seven "Beck" piezometers were installed by the SWPB along the toe of the dam in the left abutment in August 1997. An eighth "Beck" piezometer was installed by the SWPB in April 1998. Currently seven of these piezometers remain.

Three drill holes were drilled in May 1982, but two of the holes were destroyed when the spillway was rebuilt. The remaining hole is located on the south side of the spillway. Five more drill holes were drilled in November 1999. Two holes were drilled on the top of the dam embankment and three holes were drilled along the toe of the dam embankment. (See Figure 4.) Soil profiles of the drill holes and details as to how the wells were constructed are shown in Appendix D.



## **SEEPAGE MONITORING**

Seepage has been observed at two areas along the outlet channel below the spillway, and one area along the left toe. The first seep is located on the left side of the channel about 15 feet downstream of the end of the spillway. This seep produces a fairly constant clear flow of about 5 gallons per minute from an area about 3-4 feet in diameter. This seep, which is suspected to be near the outlet of the toe drain, may be flow from the drain (specific location of the toe drain has not been confirmed).

The second seepage area is about 60 feet below the end of the spillway on the left bank of the channel. This seep is about 8 feet in diameter and varies from being damp to flowing less than a gallon per minute. This seep has been observed at all pool elevations.

The third seep area is located in the left abutment at the toe of the embankment. This seepage area is approximately 25 feet in diameter and produces no surface flow. This seep is evident only from the differing vegetation on the damp soil. This seep has been observed at all pool elevations.

The monitoring wells and seepage areas at the dam are observed and monitored by the dam operator, DNRC Bozeman Regional Office, and SWPB during regular visits; and may be measured by the SWPB during annual inspections. The instruments are generally measured twice per month from May 1 to August 31, and once per month in March, April, September, and October. Measurements may be taken during the winter months (November, December, January, February) depending on weather conditions. The monitoring data is maintained by the SWPB in Helena.



## **MAINTENANCE**

The association is responsible for routine maintenance of the project. The SWPB may identify items that need maintenance or repair during the annual report.

### **ROUTINE MAINTENANCE**

To protect the dam embankment and dike and keep them in good order, the dam operator, during regular visits to the dam, will watch for and identify any potential maintenance requirements. As soon as a need is identified, the dam operator needs to schedule and perform the routine maintenance

Items that may need occasional attention include, but are not limited to:

1. *Lubrication of gate-operating mechanism.*
2. *Debris or sediment restricting the spillway inlet or the outlet works.* Accumulated debris that could affect the operation of these appurtenances should be removed at once, with all debris removed at least annually.
3. *Erosion gullies on embankment or dike.* Development of gullies should be checked immediately. Gullies should be filled, compacted and seeded. Particular attention will be paid to the abutment contact areas and the downstream face.
4. *Rodent damage.* The rodents will be removed or destroyed, and any burrows holes should be filled immediately.
5. *Upstream slope riprap.* The upstream face reservoir riprap will normally be observed annually, but may occasionally need repairs because of high water or wave action.
6. *Vegetative cover on downstream slopes and dike.* Good vegetative cover must be maintained, but large brush should be removed.
7. *Noxious weeds.* Noxious weeds on and around the dam embankment and around the reservoir should be sprayed at least on an annual basis.

8. *Clean spillway wall tops.* Spillway wall tops should be clear of any dirt, rocks, grass, brush, and overhanging vegetation.
9. *Repair joints and seal cracks in the spillway*

### **ANNUAL MAINTENANCE**

The SWPB conducts annual inspections of Cottonwood Dam and reservoir. During these inspections, any items that require maintenance are identified and recorded. Items that may need annual maintenance include the spillway, outlet works, gate, riprap, monitoring wells, and the dike. Other routine items needing immediate attention, such as removing brush will be noted.

After the inspection, the SWPB sends the association a Dam Safety Inspection Report and a Maintenance Schedule Report. The reports identify items that need maintenance and provide a schedule of when the maintenance tasks need to be completed. The association is responsible for performing the maintenance items within the times specified.

The dam operator or association members may perform the maintenance tasks. However, major repairs will likely to be handled by a contractor. The SWPB may assist in contracting for repairs and may supervise the repair work.

### **RECORD KEEPING**

The SWPB maintains records, including photographs, of all inspections and maintenance requirements. These records also include seepage monitoring observations and monitoring well measurements. Anyone who wants to review these records may do so in the SWPB's office at the Department of Natural Resources and Conservation in Helena Montana.

The dam operator will keep records of the reservoir elevations, seepage observations, seepage measurements, and any unusual conditions. These records may be reviewed at the dam operator's house.





## REFERENCES

- HKM Associates. February 1981. Phase 1 Inspection Report, National Dam Safety Program, Cottonwood Dam, Wilsall, Montana, Park County, MT-21. Prepared for the State of Montana (DNRC) under the U.S. Army Corps of Engineers National Dam Safety Program.
- HKM Associates. October 1982. Cottonwood Dam Spillway Investigation And Repair Program. Prepared for DNRC by HKM Associates, Billings, Montana.
- HKM Associates. June 1986. Cottonwood Dam Spillway Rehabilitation Project Design Report. Prepared for DNRC by HKM Associates, Billings, Montana.
- Arthun, Les, Shields Canal Company dam operator. December 1994.
- Telephone communications with David Adair, Regional Office Civil Engineer, Water Resources Division, DNRC, Billings.
- Parish, Lovell, Regional Geologist. September 1998. Geotechnical Inspection of Ruby Dam - Madison County , Montana. Prepared for the State of Montana (DNRC) by the Bureau of Reclamation, Great Plains Office, Billings Regional Office, Montana.





# **APPENDICES**



**APPENDIX A**  
**RATING CURVES AND TABLES**

**TABLE 1. SLOPE- ELEVATION-STORAGE TABLE**  
**COTTONWOOD RESERVOIR**

Table prepared by DNRC 8/27/1997.

Storage values based on 1952 original surveys of the reservoir.

The 0+00 pin is located on the south side of the operating gate concrete pad.

Top of Operating Gate Concrete Pad	5,109.0 feet
Dam Crest	5,108.7 feet
Guard Dike Crest Elevation	5,102.5 feet

DISTANCE feet	ELEVATION feet	STORAGE acre-feet		DISTANCE feet	ELEVATION feet	STORAGE acre-feet
0 Top Pin 1	5108.99	3,797		35	5099.49	1,284
1	5108.80	3,741		36	5099.19	1,229
2	5108.61	3,685		37	5098.89	1,175
3	5108.43	3,631		38	5098.60	1,125
4	5108.24	3,575		39	5098.30	1,072
5	5108.05	3,519		40	5098.00	1,020
6	5107.83	3,454		41	5097.65	976
7	5107.61	3,389		42	5097.31	933
8	5107.40	3,326		43	5096.96	890
9	5107.18	3,261		44	5096.62	849
10	5106.96	3,196		45	5096.27	807
11	5106.65	3,104		46	5095.91	765
12	5106.35	3,016		47	5095.55	728
13	5106.04	2,924		48	5095.18	689
14	5105.74	2,835		49	5094.82	654
15	5105.43	2,743		50	5094.46	621
16	5105.08	2,640		51	5094.30	607
17	5104.73	2,536		52	5094.14	593
18	5104.37	2,430		53	5093.97	577
19	5104.02	2,326		54	5093.81	563
20	5103.47	2,166		55	5093.65	549
21	5102.91	2,008		56	5093.26	513
22	5102.64	1,940		57	5092.87	481
23	5102.37	1,873		58	5092.47	453
24	5102.10	1,805		59	5092.08	426
25	5101.83	1,745		60	5091.69	398
26	5101.60	1,698		61	5091.52	386
27	5101.37	1,651		62	5091.36	375
28	5101.13	1,601		63	5091.19	363
29	5100.90	1,555		64	5091.03	352
30	5100.67	1,510		65	5090.86	342
31	5100.43	1,462		66	5090.36	313
32	5100.20	1,417		67	5089.87	285
33	5099.96	1,370		68	5089.37	256
34	5099.73	1,328				
DISTANCE	ELEVATION	STORAGE		DISTANCE	ELEVATION	STORAGE

**TABLE 2. ACTIVE STORAGE IN ACRE-FEET**  
**COTTONWOOD RESERVOIR**

<b>ELEV</b>	<b>0.0</b>	<b>0.1</b>	<b>0.2</b>	<b>0.3</b>	<b>0.4</b>	<b>0.5</b>	<b>0.6</b>	<b>0.7</b>	<b>0.8</b>	<b>0.9</b>
<b>5,072</b>	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
<b>5,073</b>	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9
<b>5,074</b>	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9
<b>5,075</b>	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9
<b>5,076</b>	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9
<b>5,077</b>	5.0	5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.8	5.9
<b>5,078</b>	6.0	6.2	6.4	6.6	6.8	7.0	7.2	7.4	7.6	7.8
<b>5,079</b>	8	8	9	9	9	9	10	10	10	11
<b>5,080</b>	11	11	12	12	13	13	14	14	15	15
<b>5,081</b>	16	17	18	19	20	21	22	23	24	25
<b>5,082</b>	26	28	29	31	32	34	36	37	39	40
<b>5,083</b>	42	44	46	48	50	52	55	57	59	61
<b>5,084</b>	63	66	68	71	74	76	79	82	85	87
<b>5,085</b>	90	93	96	99	102	105	107	110	113	116
<b>5,086</b>	119	122	125	129	132	135	138	141	145	148
<b>5,087</b>	151	155	159	162	166	170	174	178	181	185
<b>5,088</b>	189	194	198	203	207	212	217	221	226	230
<b>5,089</b>	235	241	246	252	258	263	269	275	281	286
<b>5,090</b>	292	298	304	309	315	321	327	333	338	344
<b>5,091</b>	350	357	364	371	378	385	392	399	406	413
<b>5,092</b>	420	427	434	441	448	455	462	469	476	483
<b>5,093</b>	490	499	508	517	526	535	544	553	562	571
<b>5,094</b>	580	589	598	607	616	625	634	643	652	661
<b>5,095</b>	670	680	691	701	712	722	733	743	754	764
<b>5,096</b>	775	787	799	811	823	835	847	859	871	883
<b>5,097</b>	895	907	920	932	945	957	970	982	995	1007
<b>5,098</b>	1020	1037	1055	1072	1090	1107	1125	1142	1160	1177
<b>5,099</b>	1195	1213	1231	1250	1268	1286	1304	1322	1341	1359
<b>5,100</b>	1377	1397	1417	1436	1456	1476	1496	1516	1535	1555
<b>5,101</b>	1575	1595	1616	1636	1657	1677	1698	1718	1739	1759
<b>5,102</b>	1780	1805	1830	1855	1880	1905	1930	1955	1980	2005
<b>5,103</b>	2030	2059	2088	2117	2146	2175	2204	2233	2262	2291
<b>5,104</b>	2,320									

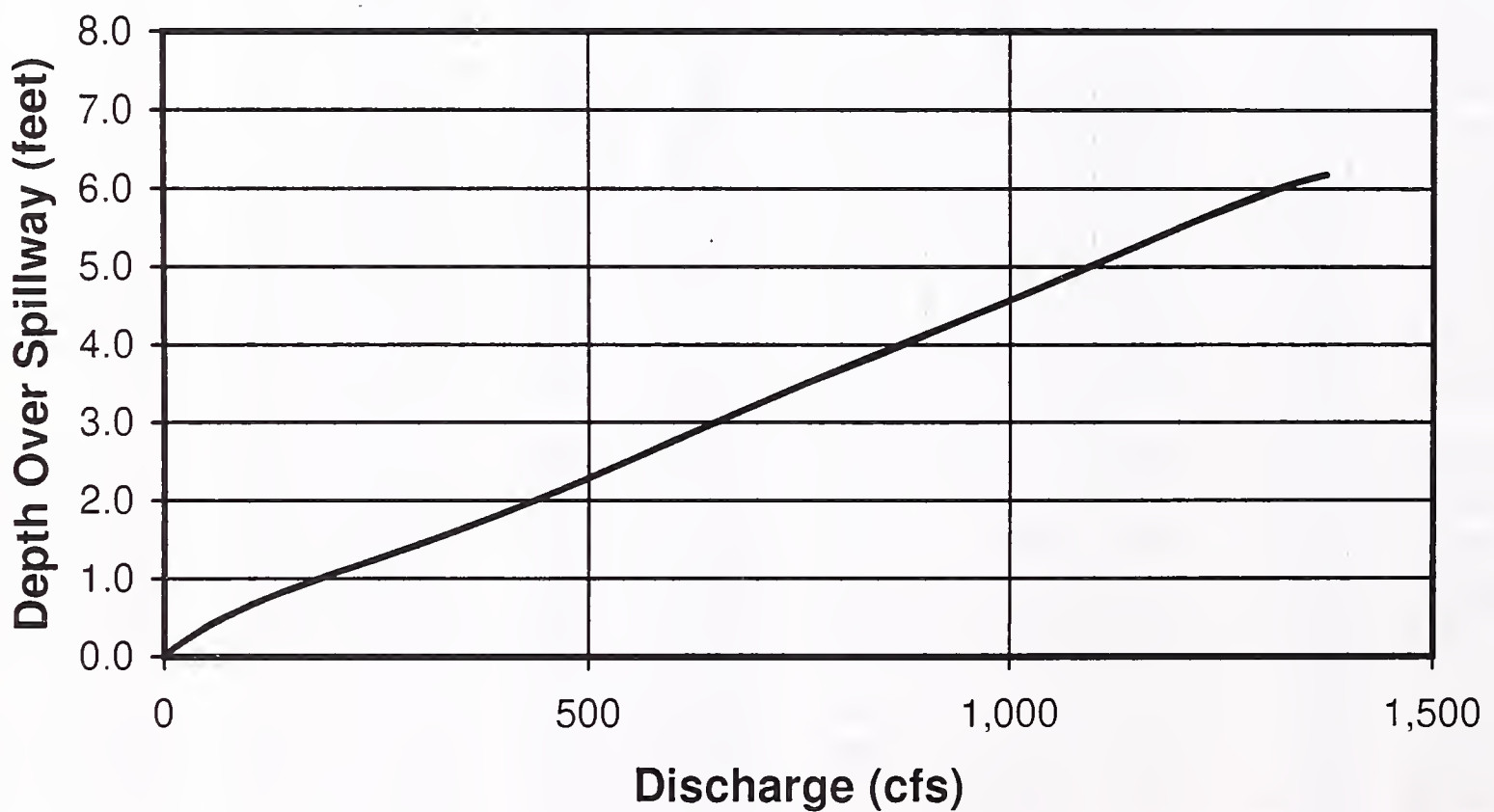
NOTE: Storage table based on 1952 original hand surveys of the reservoir.

Top of Concrete Tower Elevation --- 5,109.0 feet  
Guard Dike Crest Elevation --- 5,102.5 feet

**TABLE 3. SPILLWAY DISCHARGE**

**COTTONWOOD RESERVOIR**

Depth Over Crest (feet)	Elevation (feet)	Discharge (cfs)
0.0	5,102.50	0
0.5	5,103.00	65
1.0	5,103.50	188
2.0	5,104.50	436
3.0	5,105.50	646
4.0	5,106.50	878
5.0	5,107.50	1,088
6.0	5,108.50	1,324
6.2	5,108.70	1,375



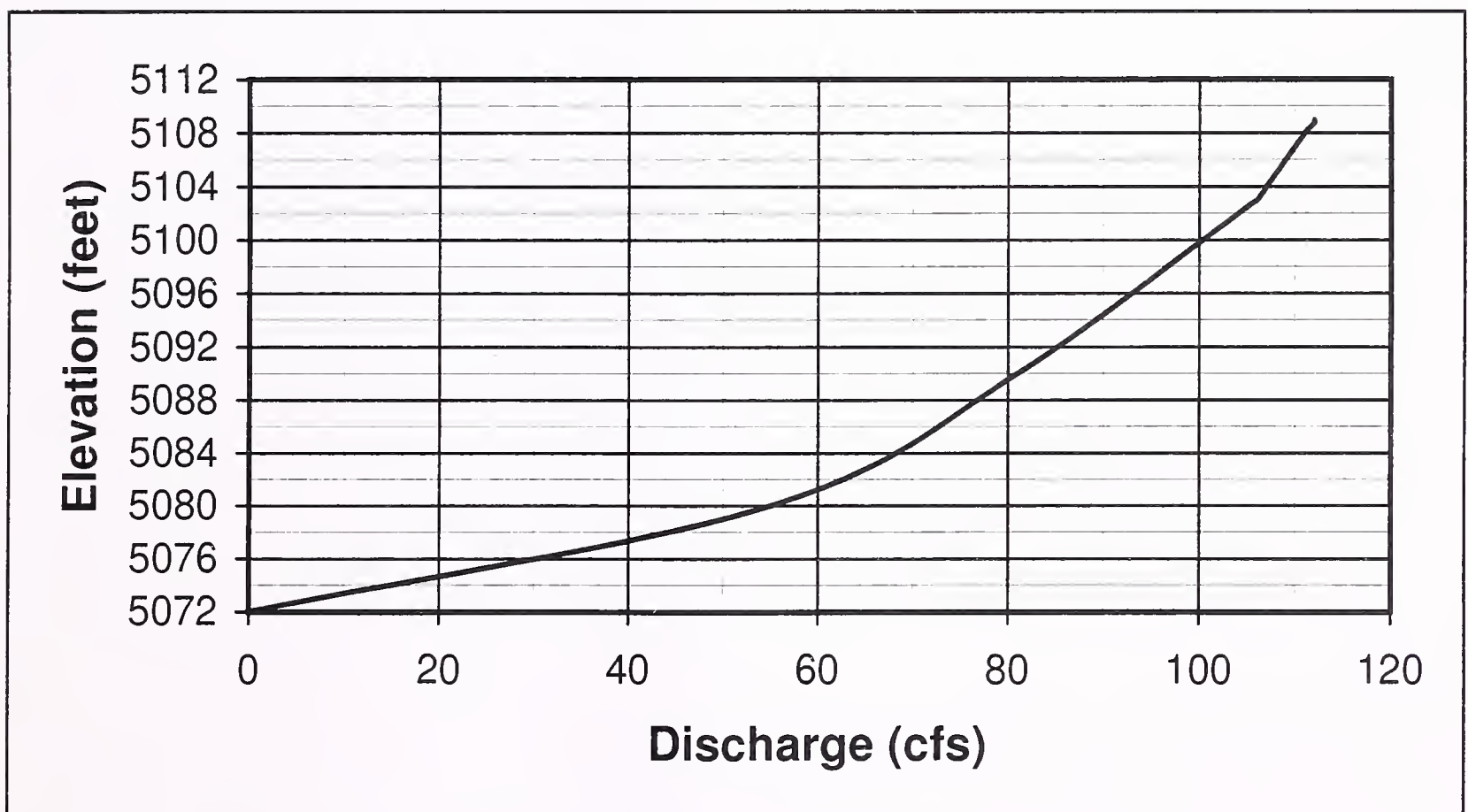
Note: Data based on spillway rehabilitation design by HKM (1986).



**TABLE 4. OUTLET DISCHARGE**  
**COTTONWOOD RESERVOIR**

Reservoir Elevation (feet)	Discharge (cfs)	Comment
5072	0	
5080	55	
5090	81	
5102.5	105	Guard Dike Crest
5103	106	
5104	107	
5105	108	
5106	109	
5107	110	
5108	111	
5108.74	112	Minimum Dam Crest
5109	112	

Note: Discharge assumes operating gate is completely open.



Note: Data from the Corps of Engineers Phase 1 Inspection Report (1981).



**APPENDIX B**  
**INSPECTION REPORT FORM**

DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION  
DAM SAFETY INSPECTION REPORT

NAME OF DAM \_\_\_\_\_  
DATE INSPECTED \_\_\_\_\_

INVENTORY NO. \_\_\_\_\_  
HAZARD CATEGORY \_\_\_\_\_  
TYPE OF DAM \_\_\_\_\_  
YEAR BUILT \_\_\_\_\_

OWNER \_\_\_\_\_  
OPERATOR \_\_\_\_\_  
STREAM \_\_\_\_\_  
DRAINAGE AREA \_\_\_\_\_

Reservoir Storage Status

	Water Surface Elevation (feet)	Storage (acre-feet)
At time of inspection	_____	_____
At spillway crest	_____	_____
At min. dam crest elevation	_____	_____

ITEM	YES	NO	REMARKS
------	-----	----	---------

**1. EMBANKMENT**

A. Crest -- Height=      Length=      Width=

(1) Any visual settlements?			
(2) Any misalignments?			
(3) Any cracking?			
(4) Any traffic damage?			
(5) Other?			

ITEM	YES	NO	REMARKS
------	-----	----	---------

1. EMBANKMENT (continued)

B. Upstream Face -- Slope=

(1) Any erosion?			
(2) Any longitudinal cracks?			
(3) Any transverse cracks?			
(4) Is riprap protection adequate?			
(5) Any stone deterioration?			
(6) Any visual settlement, slumps, sloughing, depressions or bulges?			
(7) Adequate grass cover?			
(8) Debris on the dam face?			
(9) Other?			

C. Downstream Face--Slope=

(1) Any erosion?			
(2) Any longitudinal cracks?			
(3) Any transverse cracks?			
(4) Any visual settlement, slumps, sloughing, depressions or bulges?			
(5) Is the toe drain dry?			
(6) Are the relief wells flowing?			
(7) Any boils at the toe?			
(8) Any seepage areas?			
(9) Any traffic or animal damage?			
(10) Any burrowing animals?			
(11) Adequate grass cover?			
(12) Other?			

D. Amount and Type of Vegetation on the Dam

--



ITEM	YES	NO	REMARKS
------	-----	----	---------

## 2. ABUTMENT CONTACTS

A) Any erosion?			
B) Any visual differential movement?			
C) Any cracks?			
D) Any seepage present?			
E) Other?			

## 3. OUTLET WORKS

A. Intake Structure -- Size=

(1) Any settlement?			
(2) Any tilting?			
(3) Do concrete surfaces show:			
a. Spalling?			
b. Cracking?			
c. Erosion?			
d. Exposed reinforcement?			
(4) Do joints show:			
a. Displacement or offset?			
b. Loss of joint material?			
c. Leakage?			
(5) Metal appurtenances:			
a. Any corrosion present?			
b. Any breakage present?			
(6) Trash rack?			
a. Condition?			
b. Anchor system secure?			
(7) Other?			

ITEM	YES	NO	REMARKS
------	-----	----	---------

### 3. OUTLET WORKS (continued)

B. Conduit -- Type =

Size =

(1) Do concrete surfaces show:			
a. Spalling?			
b. Cracking?			
c. Erosion?			
d. Exposed reinforcement?			
(2) Do joints show:			
a. Displacement or offset?			
b. Loss of joint material?			
c. Leakage?			
(3) Is the conduit metal?			
a. Any corrosion present?			
b. Protective coatings adequate?			
(4) Is the conduit misaligned?			
(5) Any calcium deposits?			
(6) Other?			

### C. Gates and Tower

(1) Gates:			
a. Size: Operating:		Emergency:	
b. Type: Operating:		Emergency:	
(2) Controls operational?			
(3) Controls lubricated?			
(4) Operational problems?			
(5) Leakage around gates?			
(6) Condition of gate seals?			
(7) Any cavitation damage? If so, describe?			
(8) Describe air vent-size and condition.			

ITEM	YES	NO	REMARKS
------	-----	----	---------

### 3. OUTLET WORKS (continued)

#### C. Gates and Tower (continued)

(9) Is there a jet pump?			
a. Is it operational?			
b. Leakage?			
(10) Is the tower dry? ____ wet? ____			
(11) Any seepage in the tower?			
(12) Condition of the tower?			
(13) Any safety problems?			
(14) Ladder in good condition?			
(15) Condition of the gatehouse?			
(16) Emergency plan completed for the dam?			
a. Posted in the gatehouse?			
(17) Other?			

#### D. Stilling Basin

(1) Do concrete surfaces show:			
a. Spalling?			
b. Cracking?			
c. Erosion?			
d. Exposed reinforcement?			
(2) Do joints show:			
a. Displacement or offset?			
b. Loss of joint material?			
c. Leakage?			
(3) Do energy dissipaters show:			
a. Signs of deterioration?			
b. Are they covered with debris?			
(4) Other?			



ITEM	YES	NO	REMARKS
------	-----	----	---------

### 3. OUTLET WORKS (continued)

#### E. Downstream Channel

(1) Is the channel:			
a. Eroding or backcutting?			
b. Sloughing?			
c. Obstructed?			
(2) Is released water:			
a. Undercutting the outlet?			
b. Eroding the embankment?			
(3) Other?			

### 4. SPILLWAY

#### A. Description

(1) Location?			
(2) Type of Spillway?			
(3) Size of Spillway?			
(4) Spillway lining?			
(5) Is there a weir?			
(6) Is the spillway in good condition?			
(7) Any drains?			
a. Describe the condition of drains.			

#### B. Does spillway show:

(1) Any cracking concrete?			
(2) Any spalling concrete?			
(3) Any exposed reinforcement in the concrete?			
(4) Any erosion?			

ITEM	YES	NO	REMARKS
------	-----	----	---------

#### 4. SPILLWAY (continued)

##### 4. B. Does spillway show: (continued)

(5) Any slope sloughing?			
(6) Any obstructions?			
(7) Displacement or offset joints?			
(8) Loss of joint material?			
(9) Leakage at the joints?			
(10) Other?			

##### C. Do the energy dissipaters show:

(1) Signs of deterioration?			
(2) Any cracking?			
(3) Any spalling?			
(4) Any exposed reinforcement?			
(5) Are they covered with debris?			
(6) Other?			

##### D. Has release water:

(1) Eroded the embankment?			
(2) Undercut the outlet?			
(3) Eroded the downstream channel?			
(4) Other?			

##### E. Emergency Spillway

(1) Is there an emergency spillway?			(If YES, describe)



ITEM	YES	NO	REMARKS
------	-----	----	---------

## 5. RESERVOIR CONTROL

A) Recent upstream development?			
B) Recent downstream development?			
C) Slides in reservoir area?			
D) Change in reservoir operation?			
E) Large impoundment upstream?			
F) Any debris in the reservoir?			
G) Other?			

## 6. INSTRUMENTATION

A) List type(s) of instrumentation:			
B) In good condition?			
C) Read periodically?			
D) Is data available?			
E) Include all data gathered since last report.			

## 7. DOWNSTREAM CONDITION

A. Downstream Land Use.

--

This dam was inspected by:

**Additional comments and recommendations.**



**APPENDIX C**  
**O&M MANUAL DISTRIBUTION LIST**

## COTTONWOOD DAM O&M DISTRIBUTION LIST

	<u>Number Of Copies</u>
1. SWPB Glen McDonald Greg Ames Art Taylor (2) Bob Arrington Bob Clark Dolores Eustice	7
2. DNRC Information Services Section	1
3. DNRC Regional Office Scott Compton	1
4. DNRC Dam Safety	1
5. Water Users Alan Johnstone -- President Kathryn Arthun -- Secretary Ken Artun -- Director	3
6. Dam Operator Dam Operator (Les Arthun)	1
7. State Library -- Attn: Roberta Gebhardt	4
8. Extra	2
=====	
TOTAL	20

**APPENDIX D**

**MONITORING WELL LOGS**



## BECK PIEZOMETER TABLE

### Piezometer Table

Piez #1 Total Length = 10.00' Stick-up = 1.96' Total in ground = 8.04' Elev = 5065.28'

Piez #2 Total Length = 5.00' Stick-up = 1.35' Total in ground = 3.65' Elev = 5058.61'

Piez #3 Total Length = 10.55' Stick-up = 1.60' Total in ground = 8.95' Elev = 5059.12'

Piez #4 Total Length = 10.25' Stick-up = 2.20' Total in ground = 8.05' Elev = 5054.95'

Piez #5 Total Length = 10.22' Stick-up = 1.60' Total in ground = 8.62' Elev = 5054.11'

Piez #6 Total Length = 5.00' Stick-up = 1.10' Total in ground = 3.90' Elev = 5053.48'

Piez #7 Total Length = 10.30' Stick-up = 1.10' Total in ground = 9.20' Elev = 5050.61'

Piez #8 Total Length = 10.64' Stick-up = 1.65' Total in ground = 8.65' Elev = 5055.02'

**Note: The soil profile well logs and the drill hole completions logs for the holes drilled in 1999 have not been completed, and will be added later.**

## Drill Hole No. 6 (DH-6)

Note: Three drill holes were drilled in May 1982, but two of the holes were destroyed when the spillway was rebuilt. The remaining hole is located on the south side of the spillway. It was originally identified as DH-3, but has been renumbered to DH-6 to mesh with the drill holes drilled in 1999. See Figure 4 which shows the location of this monitoring well.

# LEGEND

W WATER CONTENT (PERCENT OF DRY SOIL WEIGHT)

N NUMBER OF BLOWS REQUIRED TO DRIVE A STANDARD 2-INCH DIAMETER SPLIT SPOON PENETROMETER 18 INCHES INTO THE SOIL BY A 140-POUND HAMMER DROPPING FREELY A DISTANCE OF 30 INCHES

PI PLASTIC INDEX (PERCENT)

K FIELD PERMEABILITY IN FT/YR (U.S.B.R. DESIGNATION E1B)

%-200 PERCENT OF SOIL PASSING THE NO. 200 SIEVE

$\gamma_d$  DRY DENSITY (LBS. PER CU. FT.)

Rec. RECOVERY (PERCENT)

RQD ROCK QUALITY DESIGNATION (PERCENT)

Qu INDICATION OF UNCONFINED COMPRESSION (T/FT<sup>2</sup>) (BY POCKET PENETROMETER EXCEPT WHERE NOTED)

$\frac{W}{L}$  RECORDED WATER LEVEL

VERTICAL SCALES:

LOG OF CORE HOLES: 1" = 1' - 0"

LOG OF EXPLORATION HOLES: 1" = 10.0'

SURVEY:

ELEVATIONS ARE LOCAL DATUM.

CREDITS:

SPILLWAY DIMENSIONS OBTAINED FROM DRAWING 703-5, SPILLWAY DETAILS, COTTONWOOD CREEK DAM, STATE WATER CONSERVATION BOARD, MARCH, 1953.

DRILL HOLE NO. 3 (DH-3)		K RQD Rec. N W		ELEV. 88.5	ELEVATION
50	0.4	10		SILT CLAY FILL; moist, stiff, sandy, brown to reddish brown	90.0
47	56			SANDSTONE; layered, very dense, greenish gray to gray, w/oxidized shaley fragments imbedded in sandstone	80.0
0	54			High water loss at 652 to 648	70.0
60	100			SANDSTONE CONGLOMERATE; slightly fractured to 653, gravel fragments, interbedded, low permeability	60.0
78	100				
100	100				
100	100				
50	100			SILTSTONE SHALE; hard, dark brown to black, w/ 3" claystone seam at 502	50.0
60	100			* RATE OF PUMP-IN FLOW EXCEEDED PUMP CAPACITY ∴ K > 1400 FT/YR	40.0
0	100			Install 2" diameter monitoring tube to elevation 335, perforated below elevation 732.	30.0
32	100				
67	100				



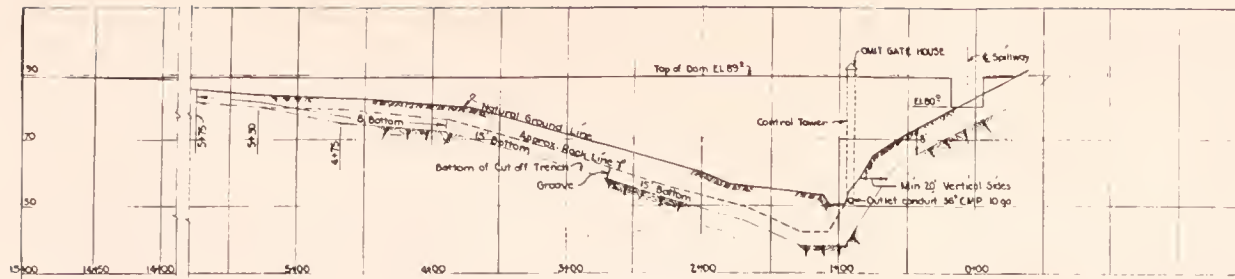
## **APPENDIX E**

### **PROJECT DRAWINGS**

**(NOTE: These reduced project drawings are design drawings and not "As Builts". These drawing should be used for reference only. The SWPB has the full size project drawings.)**

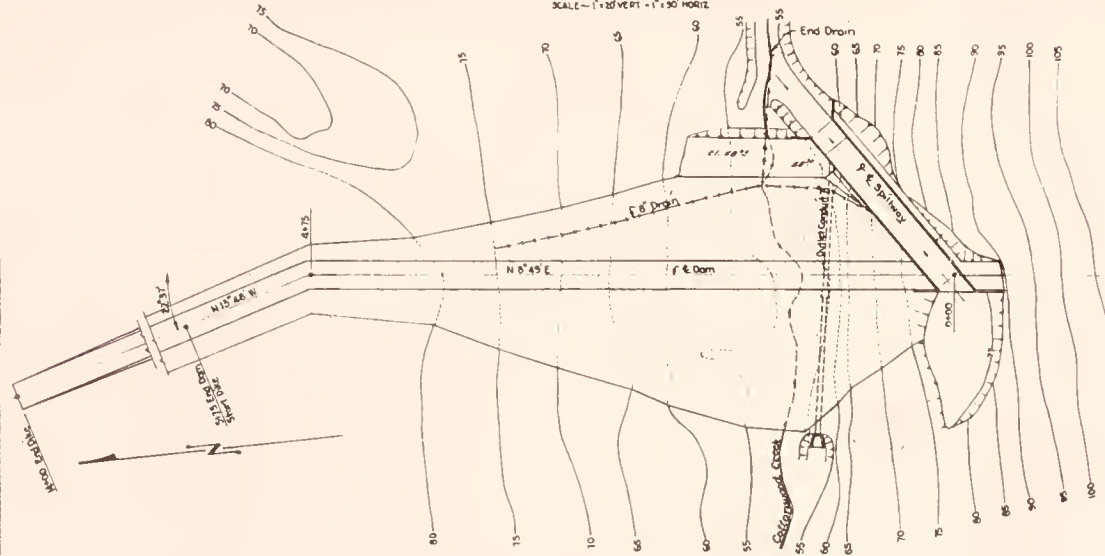






PROFILE

SCALE - 1" = 20' VERT - 1" = 30' HORIZ



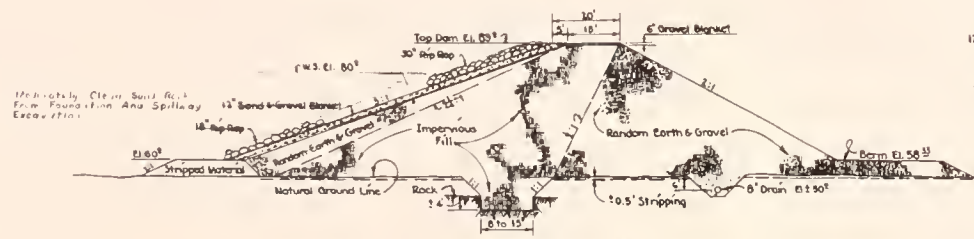
PLAN

SCALE - 1" = 50'



RESERVOIR MAP

SCALE - 1" = 500'



TYPICAL SECTION

SCALE - 1" = 10'

END OF DAM SECTION & ROCK RIP RAP AT 5+75



TYPICAL DIKE SECTION

SCALE - 1" = 10'

DIKE SECTION FROM 5+75 TO 14+00  
END GRAVEL RIP RAP AT 8+50

DETAILS OF DAM - COTTONWOOD CREEK

SHIELDS CANAL PROJECT

PARK COUNTY

STATE WATER CONSERVATION BOARD

HELENA, MONTANA

APRIL 1953

SCALE AS SHOWN

DWG. NO. 703-4



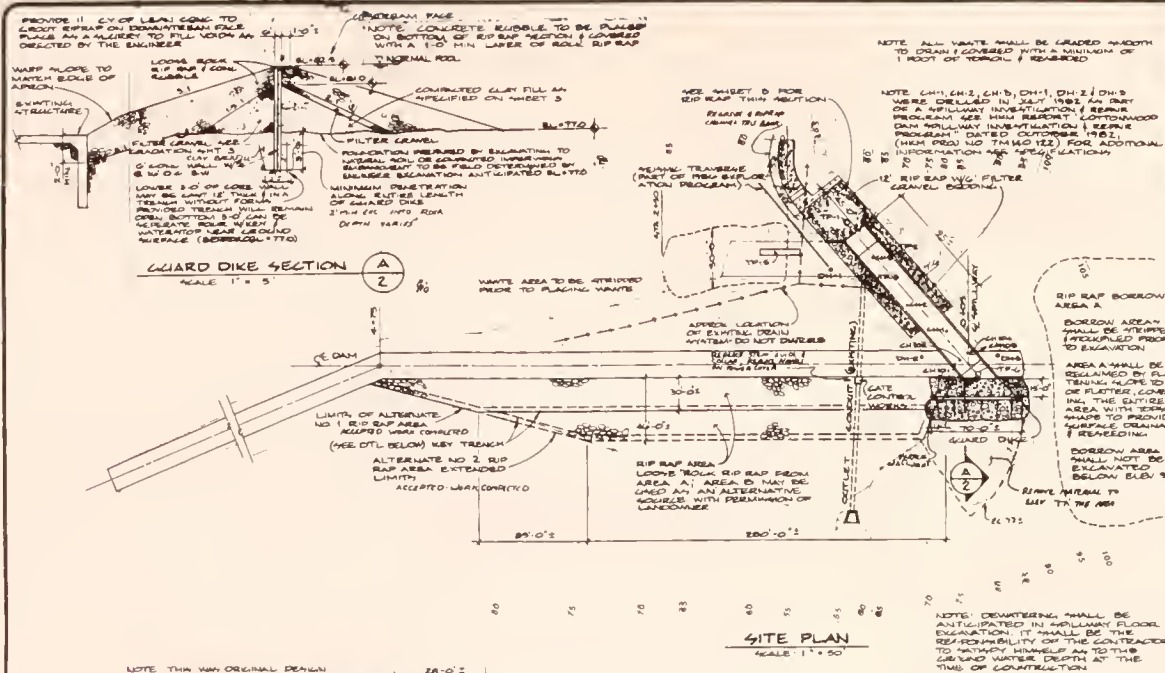




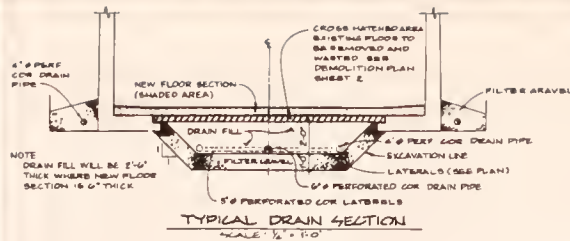












FILTER GRAVEL GRADATION SPECIFICATION	
SIEVE SIZE	PERCENT PASSING
1/4" =	100
1/2" =	70 - 100
No. 4	30 - 50
No. 20	20 - 45
No. 50	8 - 15
No. 100	2 - 15
No. 200	0 - 9

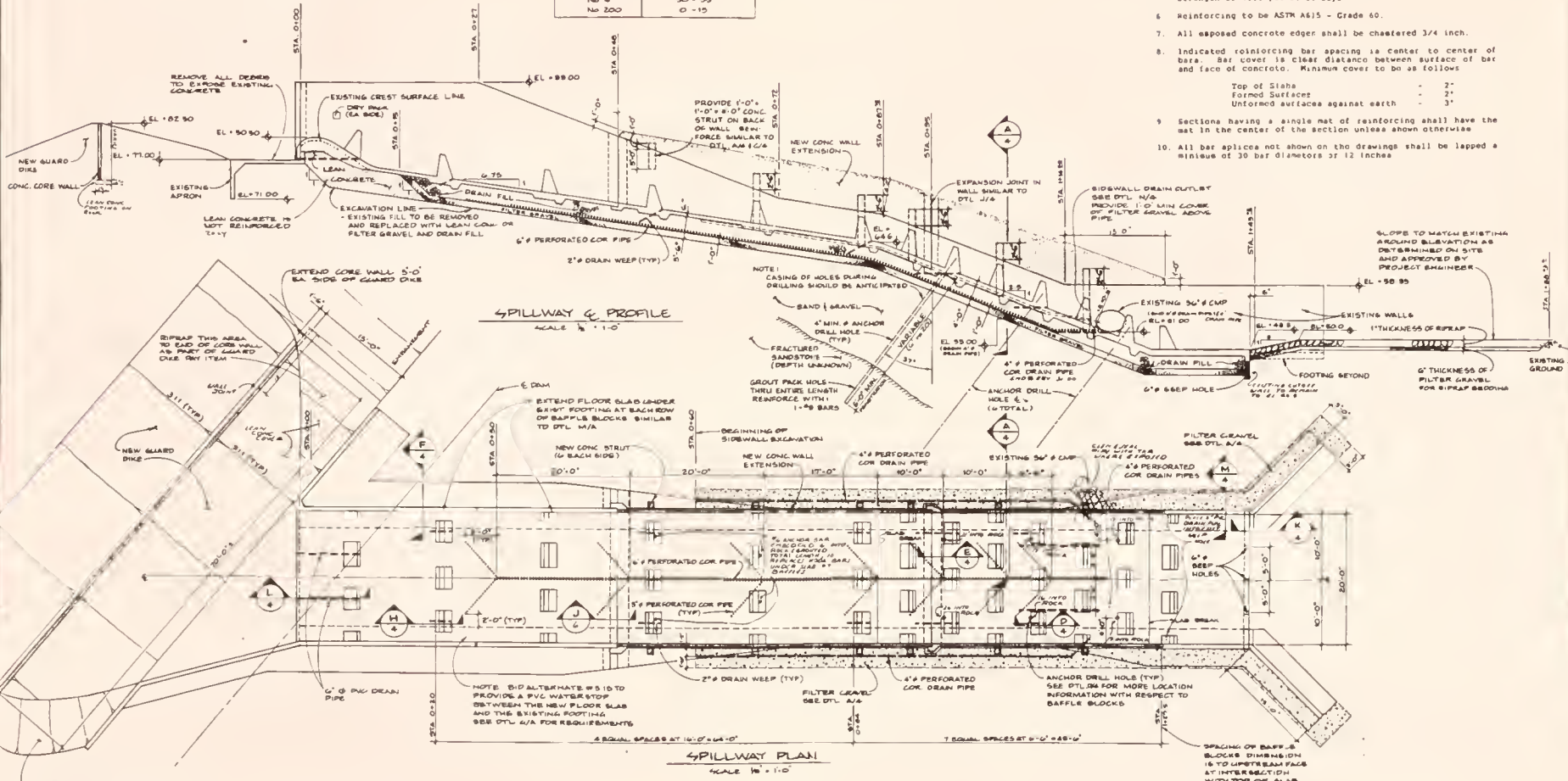
DRAIN FILL GRADATION SPECIFICATION	
SIEVE SIZE	PERCENT PASSING
1/4" =	100
No. 4	50 - 100
No. 20	20 - 40
No. 50	5 - 15
No. 100	0 - 5
No. 200	0 - 2

COARSE GRAVEL GRADATION SPECIFICATION	
SIEVE SIZE	PERCENT PASSING
3/4" =	100
No. 4	50 - 95
No. 200	0 - 15

THE COMPACTED CLAY FILL SHALL HAVE AT LEAST 90 PERCENT PASSING THE NO. 200 SIEVE. A PLASTICITY INDEX EQUAL TO OR LESS THAN 10 IS SPECIFICATION SECTION 02200.

# GENERAL NOTES

- All elevations are in feet. Benchmark is concrete base of control tower. (EL = 89.00, Project datum, not verified with MVD).
- All stationing refers to control line of construction and is the horizontal distance.
- Rock anchor lengths are shown for bidding purposes. Actual lengths will be field determined to achieve a 1 ft minimum rock penetration.
- Excavation under existing spillway slab to be a maximum of 36 inches deep or to bedrock whichever is shallower. Minimum excavation depth shall be 12 inches below lowest point of new concrete slab regardless of material encountered.
- Cast-in-place concrete shall have a minimum compressive strength of 4000 psi at 28 days.
- Reinforcing to be ASTM A615 - Grade 60.
- All exposed concrete edges shall be chamfered 3/4 inch.
- Indicated reinforcing bar spacing is center to center of bars. Bar cover is clear distance between surface of bar and face of concrete. Minimum cover to be as follows:  
Top of Slab - 2"  
Formed Surface - 2"  
Unformed surfaces against earth - 3"
- Sections having a single mat of reinforcing shall have the mat in the center of the section unless shown otherwise.
- All bar apices not shown on the drawings shall be lapped a minimum of 30 bar diameters or 12 inches.



SPREAD THIS AREA FOR WIDTH OF GUARD DIKE TO ELEV 89.00 AS PART OF GUARD DIKE. (SEE ITEM 311.1(TYP))

## SPILLWAY PLAN

SCALE 1/8" = 1'-0"

Project No. 59107-22 Date: June 1988 Designed as Drawings Checked as Approved By: [Signature]

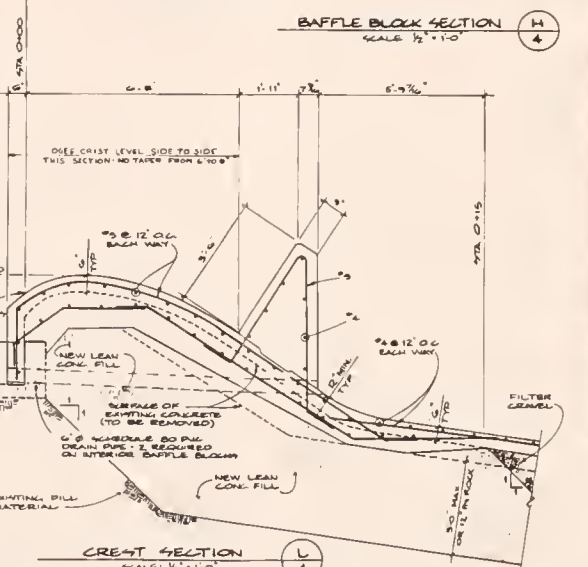
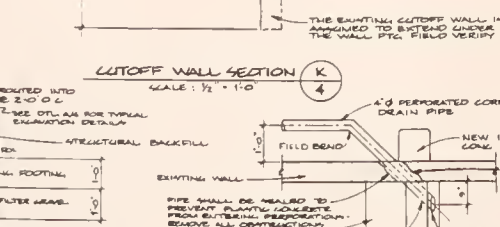
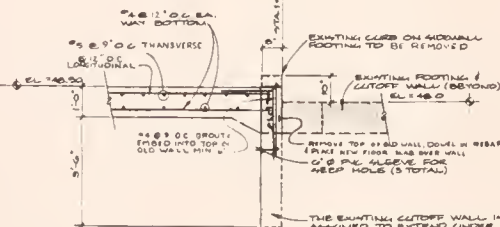
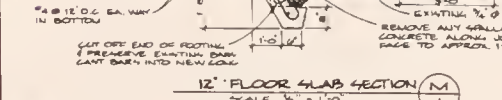
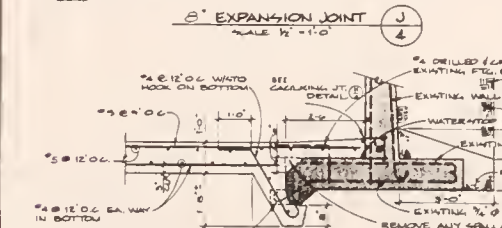
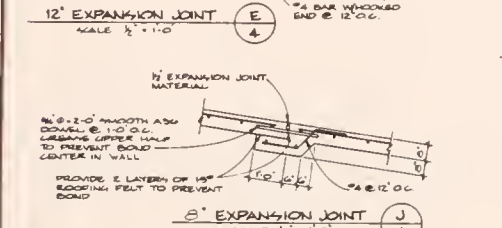
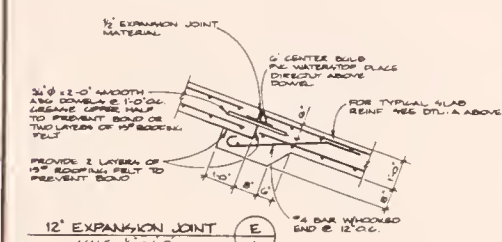
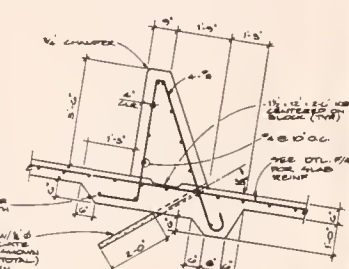
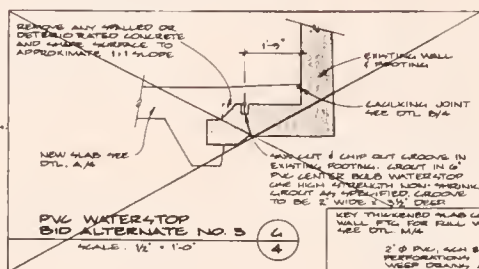
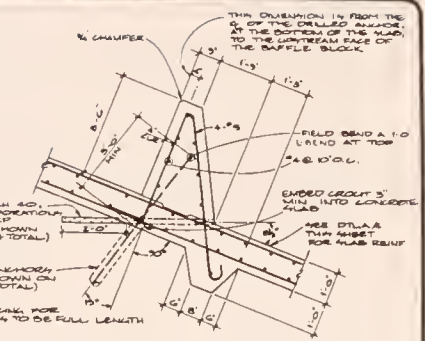
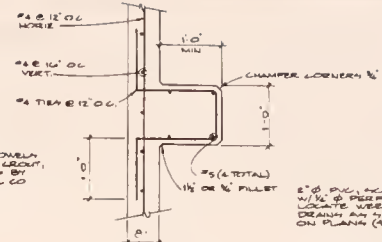
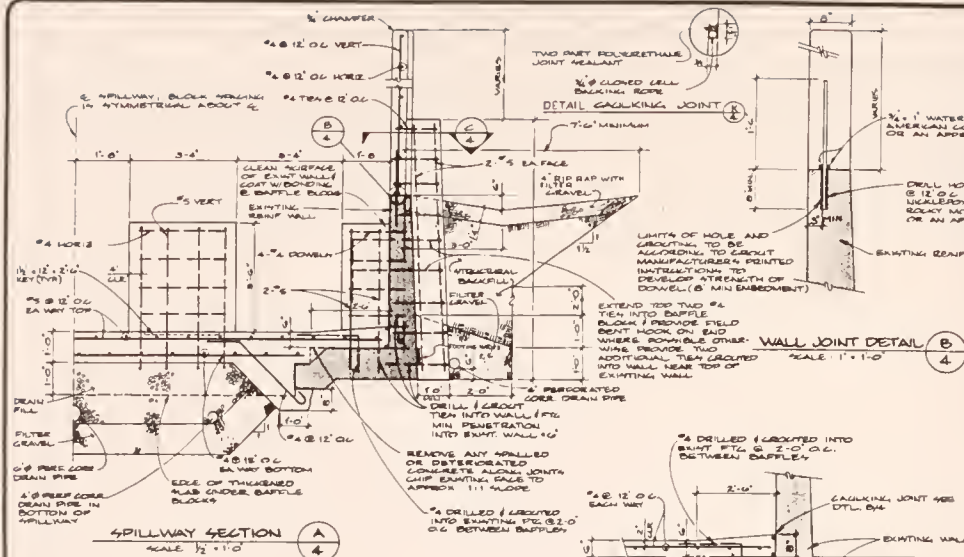
**COTTONWOOD DAM**  
**SPILLWAY REHABILITATION PROJECT**  
**PLAN AND PROFILE**

**HEKA ASSOCIATES**  
**ENGINEERS-PLANNERS**

Branch Offices:  
Airport Industrial Park  
P.O. Box 31318  
Billings, Montana 59107 • Sheridan, Wyoming







Project No.	Sheet No.	I.D. No.	Date	June 1966	Designed as	Checked as	Approved
				No.	Revision	By	Date
COTTONWOOD DAM							
SPILLWAY REHABILITATION PROJECT							
SECTIONS AND DETAILS							



**HKM ASSOCIATES**  
**ENGINEERS-PLANNERS**

Branch Office  
 • Libby, Montana  
 • Sheridan, Wyo.

Airport Industrial Park  
 P.O. Box 31318  
 Billings, Montana 59107







